$$(r_1 + r_2 + s)^{3/2} \mp (r_1 + r_2 - s)^{3/2} = 6\kappa(t_2 - t_1),$$

is ascribed to Lambert. Long ago, Tisserand called attention in his "Mécanique Céleste" to the fact that this formula was first given by Euler. To Lambert is due the corresponding formula for elliptic orbits.

In so large a volume, containing so much standard material, it is impossible to enter much into details. Nearly all the methods described are abundantly illustrated with numerical examples. As the text itself is clear and the author's style nearly always good, there would seem to be no reason why any one with the proper mathematical equipment should experience any difficulty in understanding it, which can not be said of either Watson or Oppolzer. Without doubt, it is the most valuable work on "Computational Astronomy" which we have.

W. D. MACMILLAN

Modern Microscopy. A Handbook for Beginners and Students. By M. I. CROSS and MARTIN J. COLE, Lecturer in Histology in Cook's School of Anatomy. Fourth edition, revised and enlarged, with chapters on special subjects by various writers. Chicago, Chicago Medical Book Co. 1912.

Time was when "microscopy" had a distinct place in the range of the sciences. This was, however, before the day when the microscope had become an instrument so subordinated to the scientific branches in which it is largely used. That time was marked by a lively curiosity in the world of the very small which expressed itself in the establishment of microscopical clubs, societies, journals, etc.

Popular interest in the "microscope and its revelations" seems to have been largely lost at the present day, perhaps as the detailed results of its use have become more public property. This change of attitude which seems to the reviewer a real one is for many reasons to be deplored, so that such a book as the one whose title is given above should have a distinct place as a guide book for amateur microscopists—but only as such. Attempting to cover, as it does, practically the entire field in which the microscope is applied, it necessarily falls short as a book for professional workers or serious students in the various fields.

The book is clearly written, fairly illustrated with a selection of figures, in general well chosen. The formulas of preserving fluids, stains and similar prescriptions are standard, although the selection often does not reveal a thorough familiarity with the more recent advances in the field.

Five chapters constitute Part I. on the Microscope and its Accessories. Part II., fifteen chapters, is devoted to the technique of animal and vegetable examination by means of the microscope, together with chapters on mounting entomological specimens, crystals, diatomes, etc. Part III. comprises special chapters by special writers on The Petrological Microscope, Rotifers, Mites, Foraminifera, Mosses and Liverworts, The Microscope and Nature Study and the Microscopy of Foods.

The book is therefore believed to have its place as a means of arousing and encouraging the interest of the layman in the world around him.

As a book for use in America, by Americans, however, it is believed that it would meet the demands that will be made of it better if it were to take some recognition of the excellent microscopes put out by such firms as The Bausch & Lomb Optical Company and the Spencer Lens Company among others. The special chapters, furthermore, deal with a peculiarly English fauna.

B. F. KINGSBURY

NUMBER OF SPECIES OF LIVING VERTEBRATES

RECENTLY I have had occasion to make an estimate of the number of known species of living vertebrates. After consultation with a number of specialists, the figures below have been fixed on as a reasonably close approximation to the truth. Thinking these estimates may be of interest to others, I send them to SCIENCE to publish for what they are worth. Such figures can not, of course, be accurate if for no other reasons than that in compiling them no attempt has been made to discriminate between forms described as species or as

subspecies or varieties, or to determine how many of the named and recorded species will ultimately have to be relegated to the scrap heap and be listed only as synonyms. Still less is the rôle of prophet assumed and an attempt made to go beyond present returns and indicate how many vertebrate species yet remain to be described, although it is believed that in the case of some orders (as, for instance, birds and mammals) reasonably good guesses might be made. The estimate is as follows:

1. Mammals	7,000
2. Birds	20,000
3. Crocodiles and turtles	300
4. Lizards	3,300
5. Snakes	2,400
6. Frogs and toads	2,000
7. Salamanders	200
8. Fishes	12,000
Total	47,200

H. W. Henshaw

Washington, D. C.,
August 5, 1912

SPECIAL ARTICLES

ON THE SIGNIFICANCE OF VARIETY TESTS

In the United States, considerable money and effort have been devoted to "variety tests." This has been done upon the assumption that the relative yield of a given variety in one year is a reasonably good criterion of its relative value in a subsequent year. But to some of us, the value of variety tests as they have been carried out by many of our state agricultural experiment stations seems very doubtful.[1]

The utility of a test of n varieties is measured by the correlation between the yields of the individual varieties for different years. If the correlation be 0, the yield of a variety in 1912 furnishes no criterion of its probable productiveness as compared with others in 1913. If the correlation be high, then the prediction of yield from one year's test may be made with great certainty.

Let us apply this test to a series of data given by Hall[2] for eleven years' test of a number of varieties of wheat at Rothamsted. I presume we can look upon these tests as not only more extensive but more trustworthy than many or most of those in experiment station records.

We may assume that, aside from the errors of sampling, two kinds of influences determine observed yield: the innate capacity of the variety and the conditions of growth to which it is exposed—that is, the influences attaching to soil and season. We may correct, in part at least, for the influence of season by determining the mean yield of all the varieties for each year to the nearest tenth bushel and expressing the yield of each variety for that year as a deviation from the general yearly mean. These deviations with their signs show in concrete terms the relative superiority or inferiority of a variety for a given year. Its value agriculturally, of course, depends upon the consistency with which it maintains its superiority from year to year.

Table I. has been prepared from Professor Hall's (which is arranged according to the superiority of varieties as judged at Rotham-

[1] There are several difficulties which have been but poorly met in the problem of variety testing. The identity of the variety must be beyond question, but in many cases there may be grave doubts as to the authenticity of the identifications, and in the absence of herbarium records, it is impossible to correct errors. The organization of scientifically managed seed growers' associations may be expected to overcome this difficulty in large part. Again, varieties differ in their edaphic and climatic requirements. Tests made in one place may give results not at all applicable to other localities with different conditions. Where the tests are made by wide cooperative experiments, this difficulty may be overcome, but when work is confined to a central station its value for a diversified state is *a priori* doubtful. Third, any test is subject to the probable errors of random sampling, and for the most part we have been given no means of estimating the magnitude of this measure of possible untrustworthiness. If the empirical measure of the desirability of a given variety is misleading in a particular year, it is of little value for predicting the probable yield of the variety in a subsequent year!

[2] Hall, A. D., "The Book of the Rothamsted Experiments," p. 66, 1905.